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SECTION OF GEOLOGY AND MINERALOGY

FEBRUARY 3, 1941

DOCTOR PAUL H. BIRD, Assistant Geologist, Board of Water Supply, New York, N. Y.: *Some Structural Features of the Hudson Valley.* (This lecture was illustrated by lantern slides.)

The tunnel of the Delaware Aqueduct passes beneath the Hudson River 5 miles north of Newburgh and traverses the broad Hudson Valley in a northwest-southeast direction at a depth below surface varying from about 600 feet to 1400 feet. The width of the valley along the tunnel line from Shawangunk Mountain on the northwest to the Highlands of the Hudson on the southeast is roughly 22 miles. It is underlain by three sedimentary formations, which are, beginning with the oldest: the Poughquag, the Wappinger and the Hudson River.

The Cambrian Poughquag consists of sandstone and conglomerate thoroughly cemented with quartz, and is commonly spoken of as a quartzite. Some beds are arkosic, but for the most part it is essentially a pure siliceous rock. Bedding is usually more prominent in the upper part than in the lower. The thick-

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ness has been considered around 500 to 600 feet, but it is doubtful if it is more than half this in the vicinity of the tunnel line. Between it and the underlying Highlands Gneisses, there is a marked structural unconformity.

The Wappinger is a limestone formation of Cambro-Ordovician age that lies conformably above the Poughquag. The thickness is usually given as about 1000 feet, but tentative measurements in the tunnel indicate that this is considerably too small. Parts of the formation are essentially massive, while others are strongly bedded. In general, bedding is more prominent in the upper portion of the formation than in the lower.

The Hudson River formation, of Ordovician age, is made up of black carbonaceous shale and sandstone in greatly varying proportions. Data already secured from the tunnel indicates a thickness of well over 3000 feet. It is generally considered conformable with the Wappinger. For the most part, the bedding is sufficiently plain to indicate the structure, but there are occasional short stretches of tunnel where it cannot be seen at all.

All three of these formations were involved in both the Taconic and Appalachian mountain-building revolutions, which have resulted in a very complex set of structural features with a northeast-southwest trend. Structural studies based upon the limited number of surface outcrops in this region leave much to be desired, especially regarding the details.

The excavation for the aqueduct tunnel, which is about completed at the present time, has opened up a continuous section almost exactly normal to the structural trend of the country from one side of the valley to the other. During the driving of the tunnel, geologic inspection and studies were made only at critical places where features of interest to construction were concerned. Field notes for a continuous plan and section on a scale of 20 feet to the inch are now being taken, although only a few short stretches have been covered to date. The data that have been collected, therefore, consist for the most part of a mass of disconnected details.

Two major factors have played an important role in the

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type and intensity of deformation throughout the valley. In the first place, folding, faulting and accompanying minor structures are much more prominently developed along the southeastern side of the valley and gradually become less conspicuous to the northwest, due to the fact that the centers of the disturbances were somewhere adjacent to this side of the valley. In the second place, the relative competency of the various formations and members exerted an important structural control.

The northwest front of the Highlands of the Hudson consists of a series of spurs of the crystalline rocks protruding out into the sediments with embayments of the latter in the valleys between. Three such embayments are crossed by the tunnel line. The first to the southeast is Hortontown Valley, where several slivers of quartzite are exposed. The structure here is not at all clear, except for the fact that faulting is certainly present. The tunnel is entirely in the gneisses, and the effects of faulting at tunnel grade were of no practical consequence.

In the next valley to the northwest, known as East Fishkill Hook or Trout Creek Valley, outcrops are numerous and appeared to indicate, beyond reasonable doubt, a syncline of sediments pitching to the northeast with only minor faulting. The center of the trough has been partly eroded away and a prong of Poughquag quartzite extends up each side of the valley to the southwest about a thousand feet beyond where a boring along the northwest side showed it to be absent. Recently, the contractor sank a 12-inch drill hole along the southeast side of the valley about 700 feet from the previous boring. It was thought this boring, like the other one, would be entirely in the crystallines; in fact, there was little doubt. After passing through 60 feet of overburden it encountered 20 feet of quartzite, then 50 feet of Wappinger limestone, then back into more than a hundred feet of quartzite, before finally reaching the crystallines! Needless to say that the mental disturbance, resulting from this discovery, has been of greater magnitude than whatever it was that put that quartzite and limestone where it has no business to be! The solution is certain to involve a considerable proportion of

guesswork, unless further data is obtained from the tunnel, which has not yet been driven through this stretch.

In the third embayment of sediments, known as West Fishkill Hook, quartzite outcrops along the tunnel line for about a mile, but apparently is not over 200 to 300 feet thick at any place. The tunnel here is about 600 feet deep and entirely in gneiss.

The most obvious structural break of this region is the fault, or series of faults, along which the northwest side of the Highlands has been shoved up over the sediments of the Hudson Valley. At the place where the tunnel crosses this structure, it is believed that the movement took place along two parallel faults about 200 feet apart. The one to the southeast is entirely in the gneisses at tunnel level and is marked by over a foot of gouge clay. The other, to the northwest, separates the gneisses from the Wappinger limestone and has developed only a couple of inches of gouge clay. This interpretation postulates a hidden block of quartzite representing the total thickness of the Poughquag formation between the tunnel and the surface, but there is room for it and some to spare.

After leaving the gneisses of the Highlands, the tunnel passes through a little over 9000 feet of Wappinger limestone. This block of limestone is folded, but the folds are open for the most part and the structure in general indicates a fair degree of competence. It is cut by many minor faults, none of which appear to represent appreciable displacement.

The most puzzling structure of the region, at least for the time being, is an inlier of gneiss adjacent to the above limestone block, on the northwest, and separated from it by a southeasterly dipping fault. A series of test borings about 1000 feet southwest of the tunnel line showed the gneiss to be about 500 feet wide at the surface, while, at the place where the tunnel penetrates it, it is almost exactly 1000 feet wide. The borings also showed that between the gneiss and overlying limestone there is about 35 feet, measured vertically, of Hudson River shale at a depth of about 200 feet, which appears to indicate that the limestone was

thrust up over the gneiss and, in so-doing, was overturned, or over-rode a sliver of shale. It was hoped that the tunnel would provide further evidence bearing on the character of this fault-contact, but it entered the gneiss through an east-west cross fault, the south side of which is displaced to the west, instead of through the main fault, which strikes northeast-southwest. The tunnel, therefore, was put at the wrong place—for the geologist—just like the boring in Trout Creek Valley, but, in this case, it failed to settle an old problem instead of uncovering a new one.

The thrust fault along the northwest side of the gneiss inlier brings the gneiss against the Hudson River formation and, therefore, represents a displacement greater than the combined thickness of the Poughquag and Wappinger formations, which is probably close to 2000 feet. The Hudson River, adjacent to this fault, consists partly of shale and partly of sandstone. The shale is crushed to gouge clay for a distance of about 20 feet from the fault and the sandstone is broken into blocks, which are distributed at random through the shale for a considerably greater distance.

The Hudson River formation northwest from the gneiss inlier to the second block of limestone, beginning beneath the Hudson River, is isoclinally folded throughout and stands at a high angle. The bedding, slaty cleavage, and shearing are, all three, parallel through the most of this stretch of three miles. The shale portion of the formation deformed by flowage, while the sandstone fractured. At many places, angular blocks of sandstone, representing disrupted beds, are completely surrounded by shale. The shearing, thought to be the last step in the deformation, has produced remarkably well-developed slickensides. There are almost innumerable faults and other minor adjustments throughout, the details of which have not yet been worked out.

The second stretch of limestone, which is about 7000 feet wide in the tunnel, succeeds the shale beneath the Hudson River. The contact, which dips southeast about 30°, has always been considered conformable, but deformation, consisting of flowage,

shearing, and crowding, at the place where it is penetrated by the tunnel, has obliterated the original relationship. The limestone near the contact is almost entirely recrystallized and streaks of it are sheared up into the shale. Also, at one place, a small mass of shale is sheared into the limestone. Flowage has destroyed the bedding structure in the lower several feet of the shale, but, where it can be seen closest to the contact, the dip is greater than that of the contact, and, at only a short distance away, it is almost vertical.

About a mile northeast of the tunnel, this strip of limestone splits into two branches with a wedge of the Hudson River shale between. The thrust fault that brings the limestone above the shale on the east side of this wedge extends into the limestone to the southwest and was cut by the tunnel about 2000 feet west of the Hudson River, where it had developed a crush zone 80 feet wide at a depth of 600 feet. To the southeast of this crush zone, the limestone is severely decayed and iron-stained for a distance of almost 1000 feet, although the bedding is not disturbed to any extent. Much of the decayed material could be excavated with a spade. The decay follows the bedding very sharply. In many places in the tunnel the rock is entirely sound immediately adjacent to beds that are completely decayed. The reason for this selectivity is probably compositional and studies are planned to determine, if possible, the details.

To the northwest, the tunnel passes again into the Hudson River formation. The thrust fault, situated a little over a mile west of the river, which forms the contact with the limestone, dips steeply to the northwest in the tunnel walls, but has a general dip of about 50° to the southeast. This apparent anomaly is believed to be due to the fact that the limestone broke into blocks with each succeeding higher block pushed further to the northwest.

From here to the northwestern side of Shawangunk Mountain, a distance of about 22 miles, the tunnel is continuously in the Hudson River formation, except for a stretch of 200 feet of Wappinger limestone approximately 2½ miles northwest of the

Hudson River crossing. This arch of limestone does not show on the surface at all, and probably doesn't extend above the tunnel more than a hundred feet or so.

From the thrust fault a little over a mile west of the Hudson River to Marlboro Mountain, roughly 4 miles west of the river on the tunnel line, the structure of the Hudson River formation is extremely complex. For the most part, the folding is isoclinal and slaty cleavage is well developed. Much of the rock is replete with shear and tension structures, which are filled with white crystalline carbonate and quartz, giving them a bold outline against the black and gray shale and sandstone.

Marlboro Mountain, rising to an elevation of somewhat over a thousand feet adjacent to the tunnel line, owes its presence to the fact that the Hudson River formation, from the surface to below tunnel depth at this place, is composed almost exclusively of massive sandstone. The original structural relationship of the sandstone to the rest of the formation has not yet been worked out in detail, although it is believed possible to do so from surface and tunnel data. At the present time, it appears that it represents a facies change from the shale both to the west and to the east. It also appears to be pretty well toward the top of the formation, if not at the top. The thickness is certainly well over a thousand feet at the center, and may be as much as two thousand feet. During deformation, it behaved as a competent member in comparison with the shale on both sides. In general, the structure is that of an asymmetrical syncline with low and very gradually increasing dips in the western limb, while the eastern limb dips steeply. The axis of the syncline, which is near the eastern side, is a sharp flexure that takes place in such a short distance that it could be photographed in the tunnel wall. The width of the syncline from rim to rim on the present surface is over two miles.

The lithologic character and structural habit of this part of the Hudson River formation are considered sufficiently distinctive to warrant a separate designation. In field parlance it has come to be called simply the "Marlboro sandstone," a term that suggests a separate formation, which does not appear to be justified.

However, the term "Marlboro member" is being used in field notes and, in all probability, will be used in the final geologic records of the tunnel.

An interesting and instructive incident occurred in connection with the structure of Marlboro Mountain. The flexure referred to above, which forms the axis of the Marlboro Mountain syncline, comes to the surface on top of the mountain in a valley several hundred feet wide with precipitous walls of broken sandstone over a hundred feet high. The dip in the easterly wall is about 70° west, while in the westerly wall, the bedding is about horizontal. The bottom of the valley is a swamp. The structure was interpreted as a thrust fault and a sharp lookout was maintained for its presence in the tunnel, but no fault showed up. The truth was not known until the tunnel walls were washed down preparatory to placing the concrete lining, and then it wasn't a fault any longer!

To the northwest of the sandstone of the Marlboro member, the tunnel passes through isoclinally dipping strata for a distance of about 3 miles. The dip varies from about 45° to 70° southeast. To consider this simply a continuation of the western limb of the Marlboro Mountain syncline would be to assume an immense thickness for the formation. It appears more probable that it is a series of closed folds, the one limb of each of which is overturned to the northwest. There is some, although not entirely satisfactory, evidence in the tunnel indicating this type of structure. Specimens are being collected for the purpose of making a study of grain size gradation to determine the top of the beds through this stretch.

Northwest of the isoclinally dipping strata, the folds are open and the dips gradually decrease until beneath Shawangunk Mountain there are only one or two folds with dips over 10° to 15°, and they are near the eastern front. Along with the decreasing dip of the bedding, the slaty cleavage gradually becomes less prominent and does not show up at all in the tunnel to the northwest of the Wallkill River, although, at the surface, it has been observed in a few outcrops within a mile of the base of Shaw-

angunk Mountain. For a distance of at least 10 miles northwest of Marlboro Mountain, there are stretches where shear and tension structures are prominently developed, and, in some places, are so complex as to almost defy any dependable interpretation.

The fact that this region has been subjected to two periods of compressional deformation has been mentioned. In addition, there is a possibility that it was also affected by Triassic block faulting. Efforts to differentiate the structures that may have been produced by these three periods of deformation on the basis of evidence furnished by surface outcrops, have not proved very fruitful. Accordingly, this problem has been kept constantly in mind. To the present time, no evidence whatever has been noted that may have a bearing on the age of the folding, but there does appear to be some ground for distinguishing different ages, or at least different types, of faulting.

In a stretch of about two miles of tunnel in the vicinity of the Wallkill River, faults are numerous and appear to be of three types. The first type, which is tentatively considered the earliest, always dips steeply; is accompanied by sharp, prominent drag folding; and shows no indication of crushing. These faults are often about parallel to the slaty cleavage where it is present.

The second type is invariably accompanied by crush zones consisting of comminuted rock and a mixture of crystalline carbonate and quartz. The dips vary through a great range and show a decided tendency to parallel the bedding. The slaty cleavage shows drag where this type of fault cuts it at an angle, although the drag, whether in cleavage or bedding, is not nearly so pronounced as in the first type. In many instances, tension fractures are associated with this type. Both the first and second types are thrust faults and dip to the southeast, with the displacement of the hanging wall toward the northwest. Several instances have been noted of the second type dipping gently to the northwest, with the hanging wall displaced in the same direction. In one case, a fault of the second type had displaced one of the first type.

The third type is always nearly vertical, and, in the few

instances where drag is present, appears to consist of normal faults. They are often accompanied by prominent crush zones which are filled with gouge clay and which carry no crystalline carbonate or quartz. One such crush zone is over 30 feet wide. The southeast side is always displaced down with respect to the northwest, where the direction of movement can be determined. On both sides, there is usually a well-developed set of joints parallel to these faults.

SECTION OF BIOLOGY

FEBRUARY 10, 1941

DOCTOR H. J. MULLER, University of Edinburgh and Amherst College, Amherst, Mass.: *The Threads that Weave Evolution.* (This lecture was illustrated by lantern slides.)

All the great body of work in genetics goes to establish very firmly the conclusion that the threads of nucleoprotein known as "chromosomes" form the material basis of nearly all the hereditary characters differentiating individuals of the same species from one another—the only certain exception being, in plants, characters dependent upon the chloroplastids. Nevertheless some biologists still dispute the conclusion that the differences between the species themselves, and between still more widely separated groups, are mainly determined by the chromosomes. Hence, they refuse to regard the chromosomes as the material basis of evolution, in the larger sense. Jaques Loeb, for instance, maintained that the nature of the "embryo in the rough" was ultimately determined by the cytoplasm, and assigned to the nucleus only the task of putting on the finishing touches. And the view has been recently revived that, while geographical races may be distinguished by Mendelian (hence, chromosomal) differences, which arose by mutation, the more fundamental differences between "good species" (i. e., species that cannot cross, or whose hybrids show by their sterility some deep-seated incompatibility of germ plasms) are of a quite different nature.

Reasoning "by elimination," it seems logical to suppose, with Darwin, that the change from one species to another represents merely an accumulation of these heritable variations which are found to differentiate one individual from another, just as it is logical to suppose, with Lyell, that the great geological changes of the earth represent an accumulation of the small changes visible on its surface in a single life-time. But the individual variations have been found to be due to mutations in the chromosomes (and to a lesser extent, in plants, in the chloroplastids).

If there were some other process of species formation than by accumulation of such mutational steps, the systematic studies of an army of geneticists, carried out over four decades, should, by this time, have gathered some evidence of it in their own observations of the occurrence of variations. The only large jumps observed from one "species" to another have been the origination of multiple sets of chromosomes ("polyploidy")—a process itself chromosomal in basis but largely confined to plants and obviously of very limited occurrence in past evolution,—and the origination of combination-types through crosses of preëxisting species—a process subject to similar limitations and requiring differentiation of species from each other by some more primary method in the first place. The only other escape, besides large jumps, from the conclusion that species originate, broadly speaking, by accumulation of Mendelian differences, is to go to the other extreme, and to suppose that there is a very gradual process of variation, occurring simultaneously and practically equally in all the members of the population, so as to transform it, in the course of an extremely long period, into a different species without meanwhile causing individual differences between the members of the population that are present at any one time. Not only is there no evidence for this special hypothesis, but it would encounter the difficulty that, in this case, two gradually diverging populations should, before reaching the species level of divergence, show the clearly non-Mendelian differences here postulated.

It will be seen that the above "argument by elimination" is based on the negative proposition that non-chromosomal individual differences in heredity do not exist, outside of chloroplastids. Any such negative proposition is difficult of rigorous universalization and hence should be supplemented by positive evidence. Such evidence of the chromosomal nature of the differences between species has been obtained in a number of ways. For one thing, undoubted cases of Mendelian differences between species have been obtained in some crosses; for example: in snapdragons by Baur, in cotton by Harland, in guinea pigs by Detlefson, and in the striking work on blood differences between

pigeons and doves by Cole and Irwin. The objectors to a thoroughgoing chromosomal view, confronted with such evidence, retreat to the position that, while some Mendelian differences between species do exist, that is only a part—in their view, a minor part—of the story. They would still maintain that the more fundamental differences, including especially those which cause the deep-seated species incompatibilities, such as the inability of the primary germ cells in a species-hybrid, like the mule, to undergo even the preliminary processes characteristic of the growth period, are referable to discrepancies inherent in their protoplasms. Standing in opposition to this, cases like Kosswig's and Gordon's killifish hybrids and Hollingshead's cereals, in which a Mendelizing gene of one species has been demonstrated to give rise to pathological effects, when placed in the genetic setting of the hybrid, illustrate how chromosome differences can cause such incompatibilities, but, as yet, the non-geneticists give these the status of special cases. Meanwhile, a more general analysis of species differences that might demonstrate the correctness of the chromosomal view has been hampered by two circumstances: (1) the fact that when "good" species are defined as those which are uncrossable or which give hybrids showing a deep-seated sterility, analysis of their differences by ordinary genetic methods is precluded by this very unmixability; (2) were it possible to obtain later generations from such a species cross, the gene-differences would be expected to be so numerous (as is often the case even in crosses between sub-species) as to obscure the segregation of the individual genes concerned and so to make a solution in terms of genes or chromosomes very difficult.

It is therefore desirable, for the genetic analysis of species differences, to have recourse to methods different from the orthodox ones, methods that in one way or another avoid or overleap the barrier of hybrid sterility and the mire of "multiple factors." Several such methods have been applied, with concordant results.

One such line of attack lies in the old studies of Herbst, Boveri, and others on the larval hybrids (plutei) between different species, in fact, different genera, of sea urchins (notably *Sphae-*

rechinus and *Paracentrotus*). Here it was found that, whereas the ordinary hybrids were intermediate in type, hybrids or even parts of hybrids that had received more than one set of chromosomes from the mother genus and only one set from the father, and so having abnormally large nuclei, resembled the mother genus more nearly, regardless of whether or not they had also received more cytoplasm from the mother. As a further check, it was found that larval parts of the hybrids which had received one set of chromosomes from the mother and none from the father genus, and so had abnormally small nuclei, were likewise of the mother's type. All this made it quite evident that these genus differences were dependent upon the chromosomes and not upon the cytoplasm.

In the green alga, *Acetabularia*, decisive evidence of the nuclear determination of species differences has been obtained by Hämmerling. This alga is shaped somewhat like a minute palm tree and, although it is 1 to 5 cm. high, it has all of its chromatin localized in a large nucleus in the basal rhizoid. There are two morphologically very different species of it, *mediterranea* and *Wettsteini*. When immature plants are cut in two transversely, just above the nucleus-containing region, it is possible to graft the upper (anuclear) portion from one plant on to the lower (nuclear) portion of another. When the lower part is of the *mediterranea* species and upper *Wettsteini*, then when the grafted *Wettsteini* part grows further, given enough time, it eventually forms a *mediterranea* crown while, *mutatis mutandis*, an upper *mediterranea* stem on a *Wettsteini* base forms a *Wettsteini* crown. Hence, the species morphology clearly depends on substances emanating from the nucleus below, which direct the type of growth and differentiation of the engrafted cytoplasm. At the same time, however, the chloroplastids of each species remain self-perpetuating, and disharmonies finally arise from their interaction with products of the nucleus of the foreign species.

In higher plants, where the ordinary hybrids between two species are capable of breeding at all, the descendants—the second

and later generation hybrids—show a greater range of variation than the parents, and it is possible eventually to obtain individuals resembling either parent species in respect to any chosen characteristic, although the genetic differences may be too complex to allow an analysis in terms of individual genes. That these results are due to the segregation of chromosomal genes is, however, made evident by the contrast between these cases and another great series of plant species hybrids, in which the ordinary hybrid is sterile but the hybrid with a doubled number of chromosomes (i. e., with two sets of chromosomes from each species and, hence, with four sets in all—a "tetraploid") is fertile. For in these fertile hybrids—in which each chromosome has a mate like itself, derived from the same species, and in which there is, therefore, no opportunity for segregation of chromosomes of the two species from one another—the above mentioned greater range of variation in the later generations does not occur. They breed virtually true. Thus, the segregation of the species characters must depend on the segregation of chromosomes, i. e., these characters are chromosomally determined. Moreover, the "sterility" in the first case evidently consists in an inviability of gametes and/or young zygotes, caused by the formation of incompatible chromosome combinations by Mendelian recombination.

It is evident that such experiments cannot deal with cases where the hybrid "sterility" is more deep-seated than this—consisting in a real inability to undergo the maturation processes, as in many animal hybrids. Hence, this evidence might not be regarded as fully demonstrative by those objectors who maintain that the more fundamental evolutionary steps are to be found principally in the origination of groups that show a real hybrid sterility (consisting in the inability to form gametes at all) or an uncrossability of the parent species. Such an enforced retreat as this, however, is distinctly disadvantageous to their argument. On the other hand, it should also be noted that, on account of the presence of chloroplastids in plants, it is not to be expected that determination of species differences by their chromosomes

will be complete or universal. In accordance with this, differences between reciprocal species-crosses are found in some plants. In these cases, there is clear evidence for the persistence in the cytoplasm, throughout generation after generation of back-crosses to males of a given species, of the genetic basis of characters introduced from the original mother-species. That these characters are really due to the chloroplastids rather than to other cytoplasmic elements is difficult to prove, and the peculiar conditions necessary for the proof have not yet been realized. Hence, the most decisive evidence for our thesis is, for the present, to be looked for in animals rather than in plants.

Turning to animals, a case similar to that of the plant polyploids above was long ago reported in moths by the Finnish geneticist, Federley. In *Drosophila*, a detailed analysis has been made by Dobzhansky of the results of crossing two "races," A and B, of *Drosophila pseudo-obscura*, whose hybrids in one sex (the female) are very infertile and, in the other sex, quite sterile. He used the well-known method of determining which chromosomes were present in later generations, derived from the infertile hybrid crossed to the pure species, by means of the appearance or non-appearance, in the individuals examined, of given mutant characters ("markers") of known chromosomal location, that had been present to begin with in the chosen individuals of one of the races. By this means, it was shown that the sterility and infertility were dependent upon the presence of a mixture of chromosomes. Genes tending to cause hybrid infertility were present in all the chromosomes, and only those descendants having all chromosomes of both their sets derived from one race only were fully fertile.

It would seem a quibble to object that the above experiment dealt with "races" rather than good species, for, in cases like this, there is no empirical ground for drawing a clear-cut distinction between race differences and species differences. However, in the following case, recently worked out in Edinburgh by Pontecorvo and the present author, with amplifications by Koller and Slizynski, not even such an objection can be made. For the two

groups concerned—*Drosophila melanogaster* and *Drosophila simulans*—are generally conceded to be "good species," even though morphologically similar, and their hybrids of both sexes are completely sterile, owing to an inability of the primary germ cells of either sex to even commence the growth period and maturation. This case is one in which special means were used to circumvent the first-generation hybrid sterility, by obtaining, in the very first generation, types which had chromosome compositions like those which would have been expected for the second generation, had the first generation been able to breed.

The above object was accomplished by using as the *melanogaster* parents triploid females, which, like triploids in general, produced gametes containing one or more extra chromosomes besides one complete set of chromosomes. Mutant genes for known recessive characters were provided in all the chromosomes of these triploids. The triploids were mated to normal *simulans* males that had been subjected to heavy X-raying—a procedure which we had found to result in the eventual loss, from the offspring formed, of individual chromosomes that had been present in the treated sperm. When a sperm lacking a given chromosome happened to fertilize an egg having the corresponding chromosome represented twice, a viable offspring was produced in which, as in a putative second generation hybrid, this particular type of chromosome was derived entirely from the mother species, while, at the same time, the other chromosomes were "hybrid" (having one of their two members from each species). Which kind of chromosomes had been so affected could be ascertained by noting which recessive mutant character of the mother was manifest in such an individual. In this way, it was found that the death of certain types of the hybrids was dependent upon their having a given mixed chromosome composition. Moreover, the morphological abnormalities (missing bristles, etc.) of other classes of the hybrids likewise depended on the presence together, of particular chromosomes from the two species. And, as for the hybrid sterility, all viable mixtures, in which any major chromosomes from both species were present together, showed sterility of one or another grade.

The conclusion that the sterility just mentioned was wholly due to the chromosomal make-up of these individuals, was given a complete verification by the occurrence of a single fly that had received all its major chromosomes from one species only (*melanogaster*), for this hybrid alone was found to be fertile. By breeding it to *melanogaster*, its minor chromosomes were transferred into populations that were otherwise purely *melanogaster*. A study of their characteristics, as shown under these conditions, proved that the minor chromosomes in question (the Y and the fourth) differed slightly from the corresponding *melanogaster* chromosomes in regard to the potencies of various genes. It is believed that these slight gene-differences illustrate the kind of change which, carried further, have resulted also in the hybrid sterility and in the other kinds of incompatibilities found in species crosses. At any rate, all the incompatibilities studied in the present experiment have been demonstrated to be of chromosomal origin.

The various lines of evidence recounted above, when taken together, make out a very strong case for the extension of our conclusions regarding the nature of the differences within a species to the differences between species, and so justify our designation of the chromosomes as the material basis not merely of heredity, in the narrower sense, but also of evolution, in general.

Concerning what happens within a chromosome when one of these differences arises, i. e. when a "mutation" occurs, a number of facts have been discovered. It has been found convenient to divide mutations in chromosomes into gross and minute structural changes and "gene mutations." Analysis of the gross changes produced by radiation has shown that these arise by breakage of the chromosomes at two or more points, followed by adhesion of the broken ends in a new linear order. The minute rearrangements arise in substantially the same way, except that the two breaks involved in their production are usually produced by a common cause (ionization or activation), instead of by independent accidents. As for the "gene mutations," it is not unlikely that they represent a still minuter type

of rearrangement of material, but it would be rash to maintain that the only difference between them and the above "minute changes" lies in their smaller size.

The peculiar thing about the chromosomes, which enables them to function as the material of evolution, is that, after these changes have been produced in them, when they reproduce, the daughter chromosome that is formed constitutes a faithful copy, not of the original normal chromosome, but of the newly changed pattern. That is, the existing pattern, whatever form it may have, serves as a mold or model according to which the daughter pattern is constructed. Thus, an endless number of different changes in pattern and higher combinations of these can be tried out in evolution. Extrapolating our conclusions regarding the basis of evolution to lower organisms, we would conclude that the differences between them also depend upon their chromosome-material. That is, their different protoplasms are to be considered as by-products of their chromosomes (genes). Thus, the latter would represent the primary material of life and the first essential constituent of the lowest forms of living matter, as the author pointed out in 1921 and 1926, when discussing viruses as representing relatively naked genes. This conclusion has recently received striking support from the work of Stanley, showing that tobacco mosaic and other viruses may be obtained, without loss of their potentiality of reproduction, as crystalline nucleoproteins. In other words, they consist of material having essentially the composition of chromosomes and apparently of nothing else. This finding, then, helps to justify us further in our contention that the chromosomes are the threads that weave biological evolution.

SECTION OF PSYCHOLOGY

FEBRUARY 17, 1941

MR. PAUL F. LAZARSFELD, Director, Office of Radio Research, Columbia University: *Studying the Effect of Radio.*

There has been much discussion about the changes which radio has brought, or will bring about, in American life. But few actual data are available on this point. The reason is partly that, in spite of its spectacular rise, the history of radio is still very young, and partly because studying the effect of social institutions is a very difficult task. This paper summarizes the various techniques which have been used so far to study the effect of radio.

To this end, it is necessary to state more precisely what is meant by "effect." The word has really at least four different meanings, and they can be expressed as follows:

(a) *Pre-selective effects.* It is obvious that the ultimate effect of a program depends upon whom it reaches. Radio cannot educate the broad masses of the population, if they do not listen to educational programs. An appeal for tolerance cannot have any effect, if intolerant people shy away from programs which teach tolerance. Therefore, the first step in an effect-study is to find out the audiences which the different programs attract.

(*b*) *Liked and disliked elements in programs.* Even if people are willing to listen to a program type, much of the effect will still depend upon how well the program is constructed in all its details. Therefore, methods have to be devised to find out what people like and dislike, specifically, in a given program.

(*c*) Once people are willing to try a program, and once they like it enough to continue listening, then effect-studies in the narrower sense can be carried through. One type to be studied is *short-range effects:* Does the program make people read, buy, vote, etc.?

(d) *Long-range effects.* Finally, we will be interested, and, probably, most interested in what one might call the institutional

changes which radio brings about in society. Does it increase interest in good music all over the country? Does it endanger the future of the newspaper? And so on.

Any exhaustive study of the effect of radio has to take these four types of effects into account. They can be visualized along a time-line, the pre-selective effects starting before the program is even listened to, and the long-range effects lying at the far end of the entire development. We shall now present a few examples of how such effects are measured and what has been found so far.

(1) The structure of the audience to different types of programs is, by now, well-known, and the differences are considerable. Programs, such as the Philharmonic Symphony, and "Information, Please!" are listened to relatively most frequently by upper-class people. On the other hand, programs which give advice on marital problems, cooking, and the like, have their peak-audience in low income groups. Jazz music is listened to mainly by people under thirty-five years of age; whereas religious programs are most attractive to older people. Certain leading comedians are rather universal in their appeal. Information, such as this, is gained from continual surveys of the population, which are conducted by many commercial agencies. The techniques of audience surveys have been well developed. The proportion of the population listening to a certain program is known as the "rating" of the program.

(2) Detailed program research, with the purpose of finding out what is liked and what is disliked about the program, has made much slower progress. This reporter, in collaboration with Dr. Frank Stanton of the Columbia Broadcasting System, has developed a mechanical device called the program-analyzer, as one means of discovering more precisely the portions of a program which are liked and disliked, The listener holds in his hands one green and one red button. These buttons are electrically connected with a moving tape which runs through the machine and which, in turn, is synchronized with the phonograph playing the recorded disc to which they are listening. As the listener approves or disapproves of any part of the program at any time

during its performance, he presses the green or the red button to show his like or dislike, respectively. This reaction is recorded by pens on the moving tape for each listener. When the program is over, it is possible to read the tape and thus to learn which part of the program each listener liked or disliked. When the program is played back, the listener can be asked, at each critical point, just why he liked or disliked the program at that juncture. By thus separating the mere recording of the reaction and the introspective analysis, we do not, on the one hand, break up the experience of the listener, and, on the other hand, we also keep him from forgetting what he liked and what he disliked. In this way, we secure very rich information on the effect the program produces on him, at the time of his listening. Programs which have been improved with the help of this device were liked afterwards better than they had been before.

(3) The short-range effects of radio are tested frequently by the advertisers who pay for the radio programs, since they are eager to find out whether they are selling their goods. Studies have been made of the sales of a product in cities which carry a program advertising it, and in comparable cities where the program is not on the air. Invariably, the cities with the program sell more of the advertised merchandise. It has also been shown that, where there are book programs on the air, the books discussed have greater circulation in the local libraries. The techniques of studying these short-range effects are being steadily improved. One of the latest developments along these lines has been to interview people repeatedly. During the last presidential campaign, for example, a sample of citizens was asked each month what speeches they had listened to, and what candidates they were likely to vote for, at the time of the interview. The changes in political opinion were related to the actual listening habits of these people. By and large, it can be said that radio propaganda is most successful in the commercial field and relatively less successful in the political field, because the carefully maintained neutrality of radio balances the effects of the two parties struggling for power in a typical American campaign. The very great

potential propaganda power of radio would come to the fore if it were monopolized by one side of a debate. As long as both sides have access to the radio, people usually listen, for the most part, to the side with which they agree and, therefore, the effects are minimized.

(4) What radio will do in the long run, for obvious reasons, is most difficult to predict today, partly because the effects might be very indirect. For example, it is safe to say that radio has not made people read newspapers less. Quite the contrary, by broadcasting so much news, it has probably also increased interest in news reading. At the same time, however, it has taken much advertising money away from the newspapers, and, therefore, it will probably bring about many changes and restrictions in the newspaper field, in spite of the fact that it does not reduce newspaper reading. Without doubt, radio has also greatly increased the interest in good music. As far as the system of public instruction goes, radio will probably make a great change, but it is only being accepted very slowly by schools as a legitimate help in teaching.

In appraising the future effects of radio, one has to keep in mind that a person who becomes interested in public affairs or in good music through the radio, has a different, and probably a more superficial attitude toward his new interest, than people who have been initiated to the same subjects by their immediate personal environment. Thus, there are two tendencies implied in the future of radio. One is that large masses of people will have the opportunity to participate in matters from which they have been excluded up to the present time. The other is that this participation is a looser and less stable one. Whether the future effect of radio, therefore, will be fortunate or unfortunate, depends very much upon the wisdom with which it is handled by the population, in general, as well as by educational, business, and governmental agencies.

SECTION OF ANTHROPOLOGY

JANUARY 20, 1941

DOCTOR GEZA RÓHEIM, New York, N. Y.: *Yaboaine, A War God of Normanby Island.*[1]

Yaboaine is the sky-god of Normanby Island. He appears in the role of a High God, at present, though, undoubtedly, after some confusion with Yaubada, the missionary rendering of the Biblical God (Jehovah). The narrative that figures most prominently in this connection is that of the Garden of Eden. The reason for this is obvious. Both the garden and the theft are emotionally significant things for the native, and Yaboaine is especially closely connected with theft and with punishing theft. According to Bromilow, in Dobu there are two Yaboaines. One of them is the creator; the other the patron of thieves.[2] In my Duau area, Yaboaine is rather the god that punishes thieves than the patron of thieves. He is also and, quite clearly, the voice of conscience—the *Super-Ego*. When the barau (sorcerer) is trying to kill somebody by an incantation, he first chants another incantation to close the victim's mouth and anus, so that his voice, when he calls people to help him against the sorcerers, can not come out. In consequence of this incantation, when the victim calls out for help, the people don't hear him. Yaboaine, in the sky, hears him and shouts down to the kasanumu (underworld place, the spirits of the soil) to prevent the crime. They hear Yaboaine's voice and they shout to the people, but the people don't hear what they are shouting, and so the voice of conscience has failed to assert itself.

But Yaboaine is not merely a mythological personage. He is deeply embedded in native life and ritual. When the natives have caught a pig, they will shout up to Yaboaine, "Take this

[1] This paper, here abstracted in full, was announced only by title in Transactions, Ser. II. 3, 3. Feb., 1941.

[2] W. E. Bromilow, *Twenty Years among Primitive Papuans*. p. 87. 1929.

miserable pig up for yourself, and send us better ones instead, right into the middle of our net. *Uu uu uu!*"—with a long drawn out call. The same "shouting up" occurs in all other moments at which native life reaches a climax. When they are launching a canoe, or when they have piled up the yams in the tower-like structure of the *siwapa* at the feast, they will shout up to Yaboaine, "This is really nothing what we have here. Take it up into the sky and send down one that is really loaded," or something of this kind. Especially, however, they will shout up to Yaboaine when the triumphant war party returns with a captive for the cannibal meal, "These are but weak warriors. Take them up into the sky and send men with the courage of eagles, instead." At first sight, this looks like humility, "We alone can not do much. Victory is thine, O Lord." However, we have already shown that the shouting up to Yaboaine is connected with the triumphal phases of life. Mourning, for instance, the period of *mwamwadu*, characterized by a reduction of oral activities (inferior food, no shouting, noisy talk, etc.), ends with a pig hunt, and, when the pig is caught, they "shout it up" to Yaboaine. Here we can see quite clearly what happens. A period of melancholia (the Ego bowed down under the reproaches of the Super-Ego) is ended, and, in the great deed, the achievement, in the mania phase, Ego and Super-Ego are united. If Yaboaine is the Super-Ego, the simple explanation would be that, at this phase, the Super-Ego above has to be appeased, and they are doing this by offering what they have—the yams, the pig, the war-captive.

But if we know the life and the customs of the people of Normanby Island, we soon notice that this shouting up to Yaboaine is only one instance that conforms to a general pattern. This well-nigh universal formula, the true driving force behind most of their economic efforts, is the formula of refuted reproaches. At a *sagari* or *mwadare* (food distribution ceremonies between two clans), we find the following situation: One group, those who are giving the yams, shouts towards the other group, "I am lazy and don't make a mwadare!" or "There are no chiefs in Gagayowana, only little children," or "I worked in your garden even

when the sun was shining, and you don't think of making a mwadare." These are the critical remarks made by the other group. They are now triumphantly refuted by the food distribution ceremony. This is exactly what the Super-Ego is, namely, the reproachful voice of the parents which we have introduced, transformed into a part our personality-structure. When we manage to refute these reproaches or this criticism by our achievements (or in phantasy) we are in the manic, euphoric mood of the feast-giver at the feast of the warrior who returns triumphant from war, and shouts up to the sky a projection of the Super-Ego, "So I am no good! I am not a real warrior! That's what you think! Look at the captive as proof of my victory!" So far, the situation seems to be quite clear. However, there is another aspect of Yaboaine which we have not taken into consideration. In some of the myths, Yaboaine appears as a woman. In one of the genuine witch incantations obtained from Donigo, Yaboaine in the esoteric love of the witches appears as being alternately a man and a woman. When Yaboaine appears as a woman, she is the leader of witches and, in both cases, she is on the side of the powers of destruction. This would seem to explain a peculiar feature in the ceremonial of the returning war party. For the man who leads the victim by the hand, wears a skirt. Now, the victim, the one who is to be roasted and eaten at the cannibal feast, is obviously closely connected with Yaboaine, because his spirit goes up into the sky to Yaboaine[3] or, as they say, "He became a Yaboaine." One would, therefore, assume that the captor with his skirt is identifying himself not with a god, but with the war-goddess, Yaboaine.

Here again we see how difficult it is to interpret without being personally familiar with the situation. This is a plausible explanation, yet we shall see that it is wrong. Yaboaine has a sister called Sine Mata Nogi Nogi (Woman Eyes Hard) or Silili. Sometimes this woman is not Yaboaine's sister, but identical with Yaboaine. She is, in both cases, the leader of the man-eating witches.

[3] While other spirits go to dwell on Mount Bwebweso.

The interesting thing is that "Silili" means something. It was explained to me as the "Inciter." For instance, you would say to a dog "silili," i. e. "catch him." Silili is the spirit that makes us do wicked things such as *loyawe* (love-making) war, or theft. Therefore, Silili and Yaboaine must be closely related to each other, as the *Id* is to the *Super-Ego*. More than that, however, we are told that when the war-party starts, they say to each other, "Go and catch him," i. e. "Silili." If one of these supernatural beings, who are so closely related to each other, is derived from a sentence or from the emotion of a moment (cf. Usener's "Augenblicksgötter"), it would seem natural to assume the same origin for the other. "Silili" they say, when the war party goes out, and the Yaboaine ceremony occurs, when the party returns. Yaboaine also has a meaning. There can be no doubt that it means "Ya bo wahine"—"I am a woman." When they go out, they say "Catch him," and, when they return, "I am a woman," denying their aggressions under the influence of their guilt feelings. This would be the same thing as the well known ceremonies to expell the ghost that threatens the members of the returning war party.[4] But we have the "shouting up" part of the Yaboaine complex, and this is closely connected with the *refuted reproaches* formula. We must re-interpret the sentence and say, "I am a woman" does not mean "I am a woman," but it is a refuted reproach,—"So you think I am a woman." "Now look for yourself! I am the victorious warrior!" In fact, there is one little ceremony in connection with the war party which confirms this interpretation. One man shouts to the other who wears the skirt "Why have you got a skirt on?" and he replies, "It is only a play skirt"; i. e., "I am only playing at being a woman, that is precisely what I am not."[5]

But, as we have said before, Yaboaine-Silili is also the patron goddess—the leader of all witches. These corpse-eating witches, who are initiated in a phantasied rebirth from their mother, are clearly representatives of the anxiety-aspect of infantile body-

[4] Cf. J. G. Frazer., *Taboo and the Perils of the Soul*. 1911. 165–190.
[5] Cf. for similar rites, Bateson, *Naven*. 1934.

destruction phantasies (M. Klein. For the proofs for this statement I must refer to forthcoming publications). The child has the phantasy of tearing all the good things out of the mother's body, and the corresponding *talio* or retribution-anxiety about what the "bad mother," the witch, will do to the child. There is one aspect of the Yaboaine beliefs which we have not mentioned. Yaboaine is "our maker"; but not in the Christian sense of "Creator." He is pre-eminently the God that forms the embryo in the womb. A body-destruction phantasy is that of tearing the embryo, the sibling rival, out of the womb. This is represented by the witch, who opens the grave, takes the corpse out, and re-animates it or eats it. The reparation aspect of the same phantasy is Yaboaine, who shapes and protects the embryo in the womb. And what is the Super-Ego? Not only the introduced aggression of environment, but, in its even more archaic phase, our own aggression against environment turned inwards against the Ego, and represented by the opposite.

Although I have given a philological explanation of Yaboaine as the name of a god, which is really in keeping with the traditions of Max Muller, and, although I have derived this god (or goddess) from a ritual, yet behind this situation-conditioned origin of an "Augenblicksgott," we see, revealed, the whole structure of the human *psyche* with its interrelation of Id and Super-Ego of archaic destruction and reparation phantasies.

SECTION OF PHYSICS AND CHEMISTRY

FEBRUARY 14 and 15, 1941

Conference on "*Viscosity.*"

The Section of Physics and Chemistry held a Conference on "Viscosity," the third of the series this year. Doctor H. Mark, Department of Chemistry, Brooklyn Polytechnic Institute, was in charge of this meeting as Conference Chairman.

The program consisted of the following papers:

"Introductory Remarks," by H. Mark.

"Forces and Molecular Arrangement in Liquids," by P. Debye, Cornell University.

"Viscosity of Liquids," by H. Eyring, R. E. Powell and Ch. Clark, Princeton University.

"Distribution Functions in Condensed Systems," by J. E. Mayer, Columbia University.

"Viscosity of Large Molecules in Solution," by R. Simha, Columbia University.

"Experimental Aspects of the Viscosity, Diffusion and Sedimentation of High Polymers," by E. V. Kraemer, Biochemical Research Foundation, Newark, Delaware.

THE NEW YORK ACADEMY OF SCIENCES

announces

TWO PRIZE CONTESTS FOR 1941

I

THE A. CRESSY MORRISON PRIZES

Two prizes of $200. each, offered by Mr. A. Cressy Morrison, to be known as the A. Cressy Morrison Prizes in Natural Science, will be awarded at the Annual Dinner, December, 1941, for the two most acceptable papers in a field of science covered by the Academy or an Affiliated Society.

II

THE GEORGE FREDERICK KUNZ PRIZE IN GEOLOGY AND MINERALOGY

In accordance with the terms of a bequest by the late George Frederick Kunz, the accumulated annual income of the sum of $1,000. will be offered, at intervals, by the Council of the Academy for the best paper in the field of Geology and Mineralogy. This prize, amounting to $200., is offered for the year 1941, for the first time, and will be awarded at the Annual Dinner in December.

CONDITIONS:

(1) Eligibility. For Contest I. Membership in good standing of The New York Academy of Sciences or one of the Affiliated Societies, prior to submission of the manuscript.

For Contest II. Open only to members of The New York Academy of Sciences, in good standing prior to submission of the manuscript.

(2) Date. Papers are to be submitted on or prior to November 1, 1941, to the Executive Secretary of The New York Academy

of Sciences at The American Museum of Natural History, Central Park West at 79th Street, New York City.

(3) Papers. All papers submitted must embody the results of original research not previously published. The manuscript shall be typewritten, in English, accompanied by all necessary photographs, drawings, diagrams and tables, and shall be ready for publication. Papers must be accompanied by a summary of the data presented and conclusions reached.

(4) Awards. The awards shall be made by the Council of The New York Academy of Sciences. If, in the opinion of the judges, no paper worthy of a prize is offered, the award of a prize of prizes will be omitted for these contests.

(5) Publication. The Academy shall have first option on the publication of all papers submitted, unless especially arranged for beforehand with the authors, but such publication is not binding on the Academy.

(6) Wherever and whenever published, the papers awarded the prizes in Contest I shall be accompanied by the statement: "Awarded an A. Cressy Morrison Prize in Natural Science in 1941 by The New York Academy of Sciences."

Wherever and whenever published, the paper awarded the prize in Contest II shall be accompanied by the statement: "Awarded The George Frederick Kunz Prize in Geology and Mineralogy in 1941 by The New York Academy of Sciences."

Such statement in substance must also accompany any formal publicity initiated by the author regarding the prize paper. If published elsewhere, six copies of each prize paper must be deposited shortly after publication with the office of The New York Academy of Sciences.

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Central Park West at 79th Street
New York City

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Recording Secretary

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STUDENT MEMBERS

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Gross, Jerome, B.S., Graduate Student, Biophysics, New York University, College of Medicine, New York, N. Y.

Marcy, Donald E., B.S., Assistant, Comparative Anatomy, American Museum of Natural History, New York, N. Y.

Stead, Frank W., M.A., Graduate Student, Columbia University, New York, N. Y.